Construction, calibration and validation of a macro-epidemiological surveillance indicator at a national level from wastewater analysis.

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Somewhere-World — January 19, 2022

Webinar IDO

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A nationwide indicator to smooth and normalize heterogeneous SARS-CoV2 RNA data in wastewater

Nicolas Cluzel[1⋆], Marie Courbariaux[1], Siyun Wang[1], Laurent Moulin[2], Sébastien Wurtzer[2], Isabelle Bertrand[3], Karine Laurent[1], Patrick Monfort[4], *Obépine* consortium[a], Christophe Gantzer[3], Soizick Le Guyader[5], Mickaël Boni[6], Jean-Marie Mouchel[7†], Vincent Maréchal[8†], Grégory Nuel[9,1†], and Yvon Maday[10⋆†]

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Is an interdisciplinary research group aiming at defining a macro epidemiological indicator from wastewater analysis

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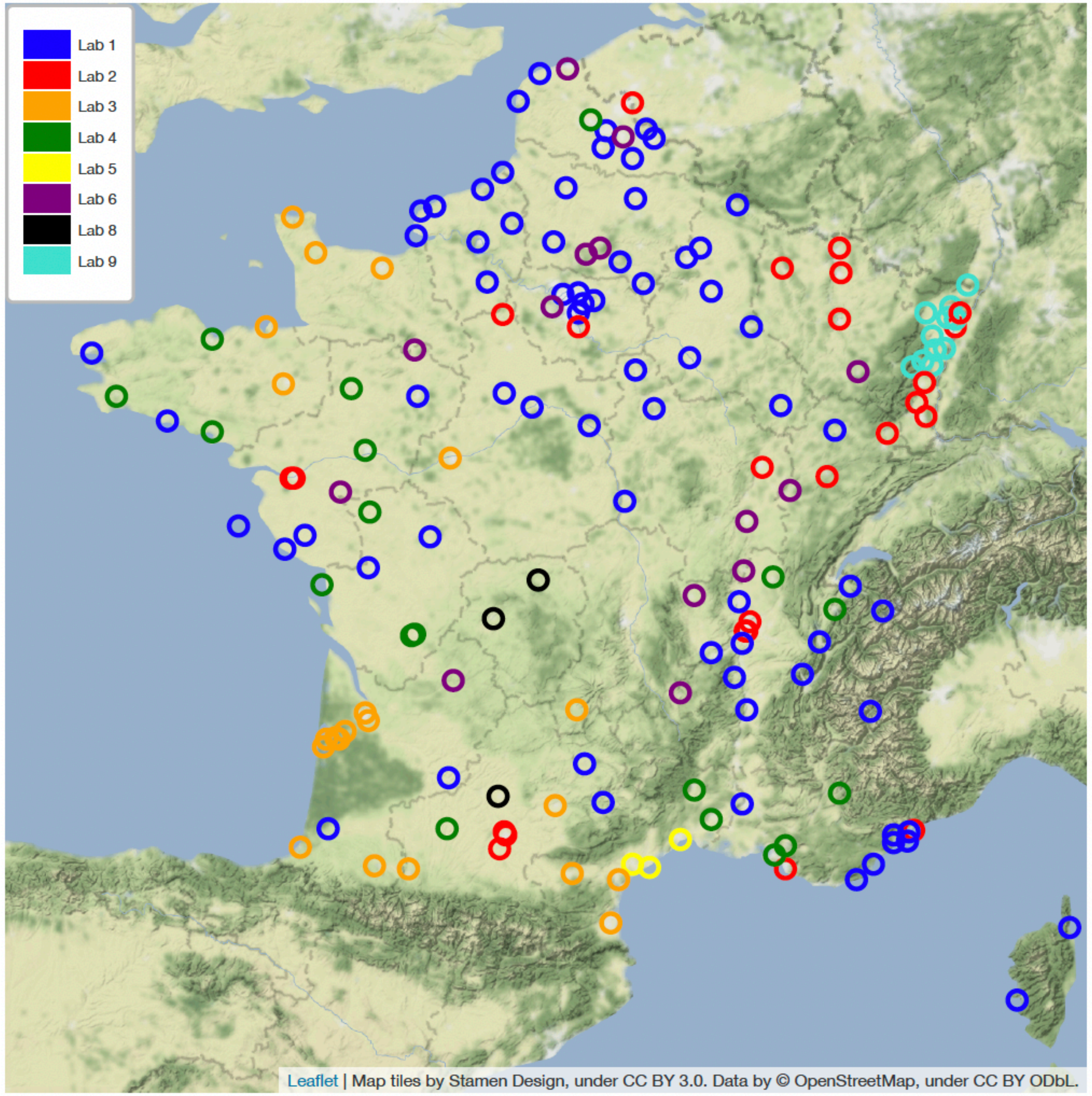
based on 6 main steps :

- qualification of the presence of the gene of the virus in wastewater at a low LOD
- quantification of the concentration of the trace of virus
- interpretation to get rid of the inherent errors
- transforming this in a reliable indicator in tendencies
- choice of the WW treatment plans
- homogenising it to propose a nation wide indicator

Currently following 200 WWTP



on 9 different laboratories

Map of the WWTPs included in the Obépine monitoring network together with the corresponding laboratories responsible for the analyses.

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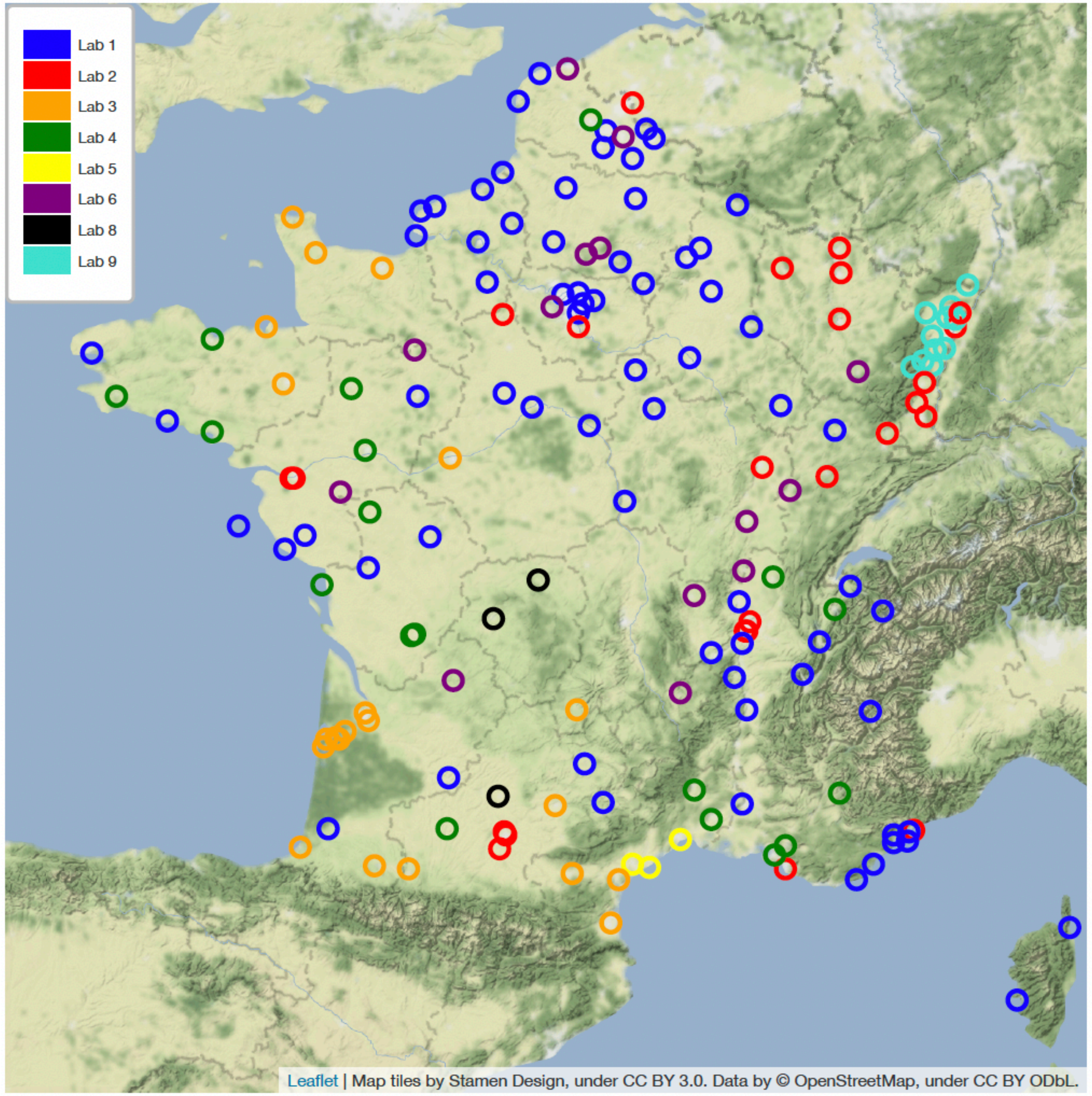
Currently following 200 WWTP

on integrated sampling our 24 h



on 9 different laboratories

twice a week

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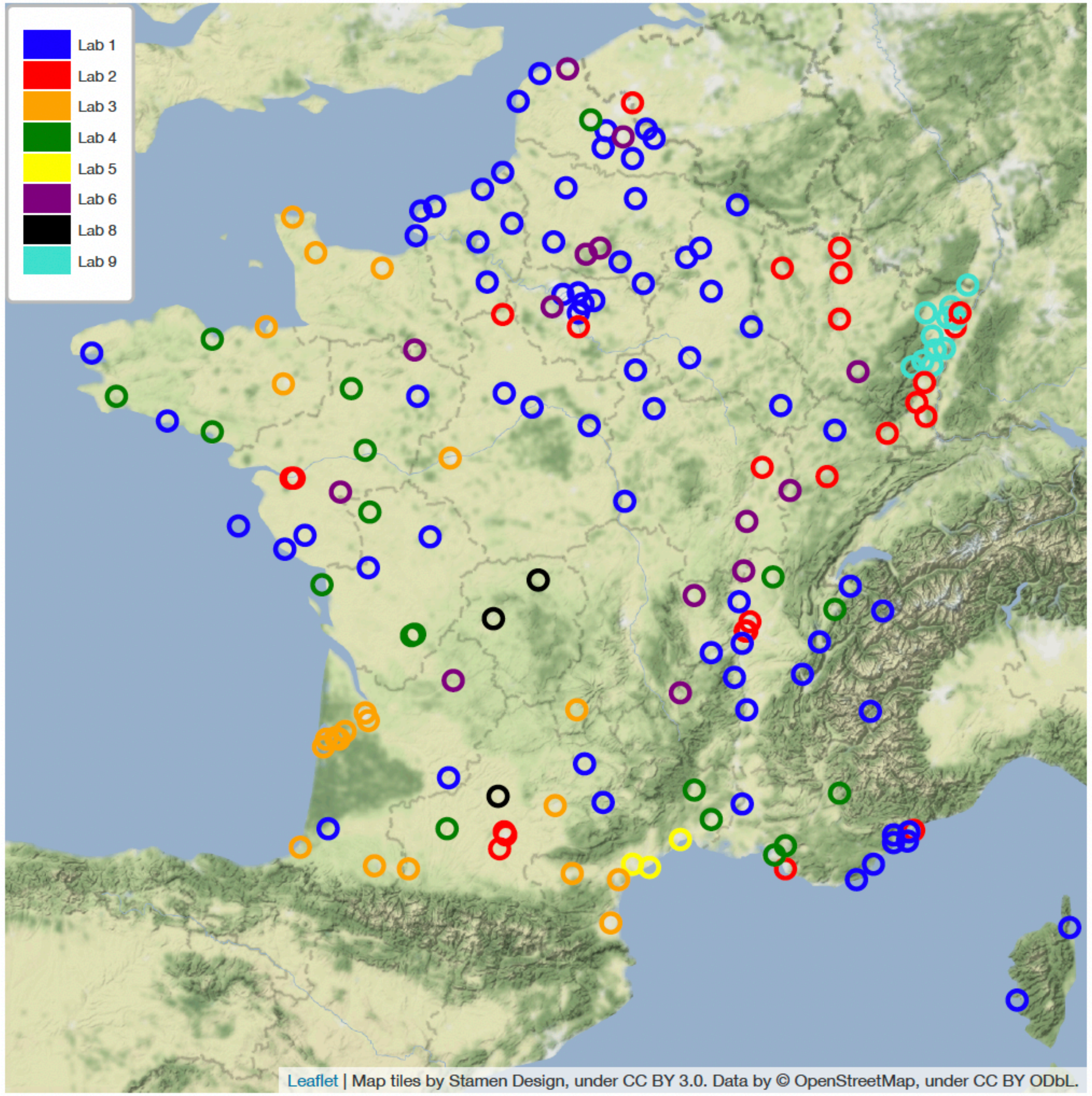
E and RdRp genes



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twice a week

reports sent to collectivities and MSS

Map of the WWTPs included in the Obépine monitoring network together with the corresponding laboratories responsible for the analyses.

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Currently following 200 WWTP

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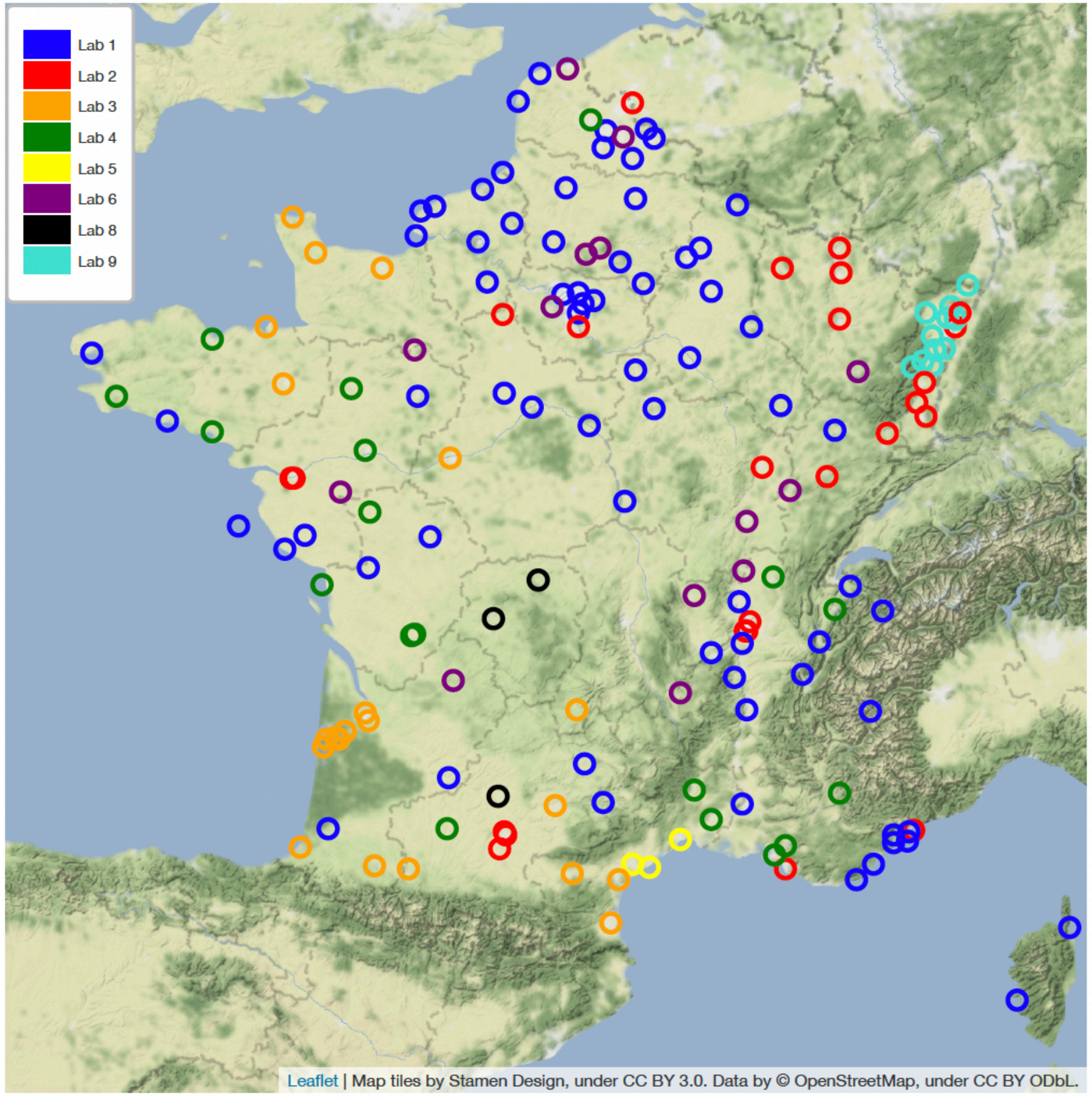
E and RdRp genes

+ characterization of variants



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reports sent to collectivities and MSS

Alpha, Delta, Omicron..

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For the quantification

The concentrations are normalised

by taking into account additional data

$$C_t = (C_{0,t})_1 \times \left(\frac{V_t}{V_0}\right)_2 \times \left(\frac{Poll_0}{Poll_t}\right)_3$$

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different quality indexes

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volume of wastewater reaching the WWT

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different quality indexes

This factor is a function of ammonium, COD and conductivity concentrations, normalised by their mean dry weather value

Smooth out and normalize heterogeneous SARS-CoV2 RNA data in wastewater

We have developed a Kalman-smoothing algorithm adapted for the Obepine data.

This one allows to find an autoregressive process of which we observe only a noisy and censored version.

$$
\begin{aligned}
X_i &= \eta X_{i-1} + \delta + \sigma \mathcal{N}(0,1) \\
Y_i' &= X_i + \varepsilon \mathcal{N}(0,1) \\
Y_i &= \max(Y_i', c)
\end{aligned}
$$

In our case, we are looking for an estimate of the "real" concentrations in the wastewater, X, of which we only observe noisy and censored measurements, Y .

The proposed method also allows to provide the a posteriori law of the underlying process, and thus intervals in which the "true" concentration is found in 99%, 95%, 50%, . . . of the cases.

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$Y_t = \log(C_t)$. Y_t is generally only partially observed

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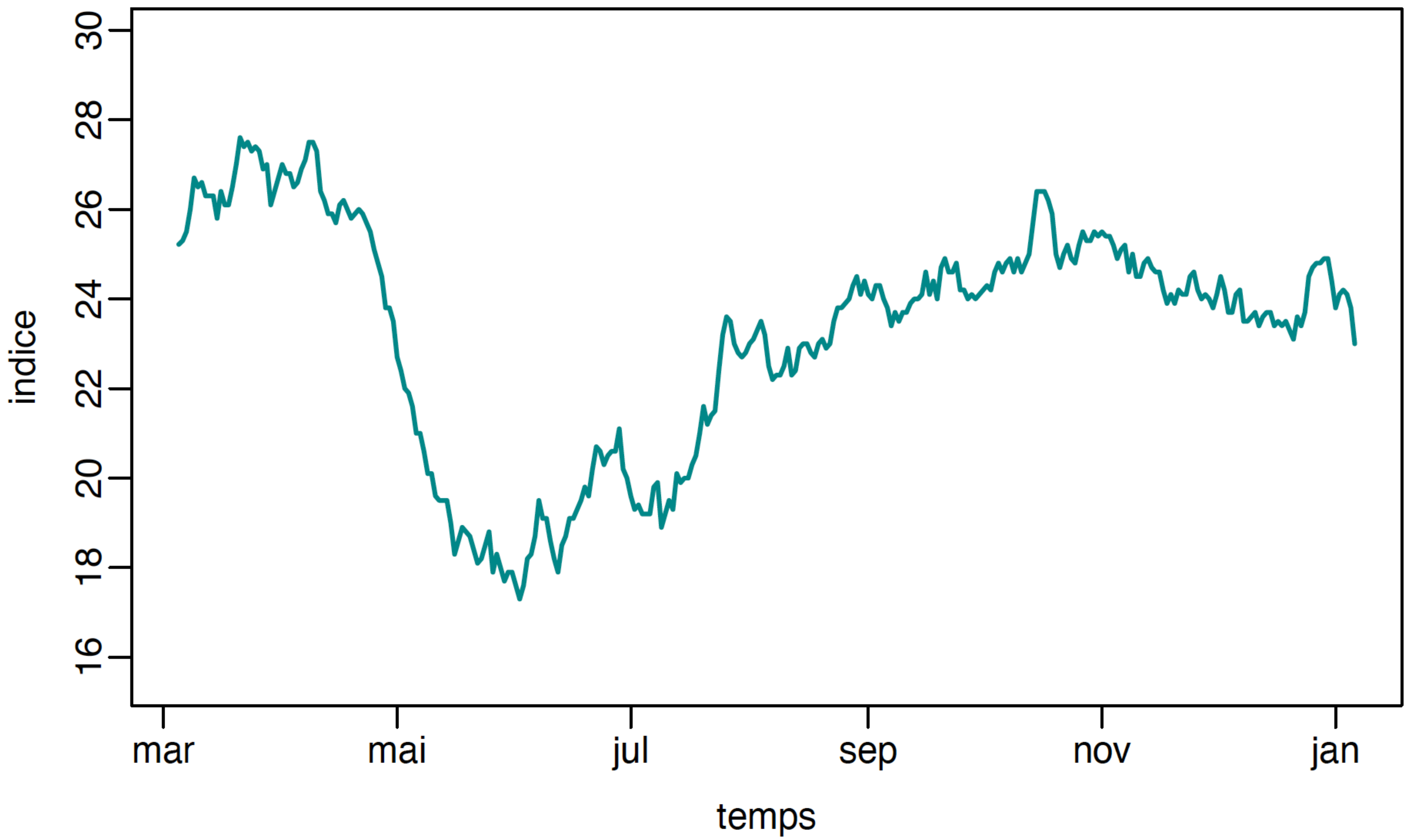
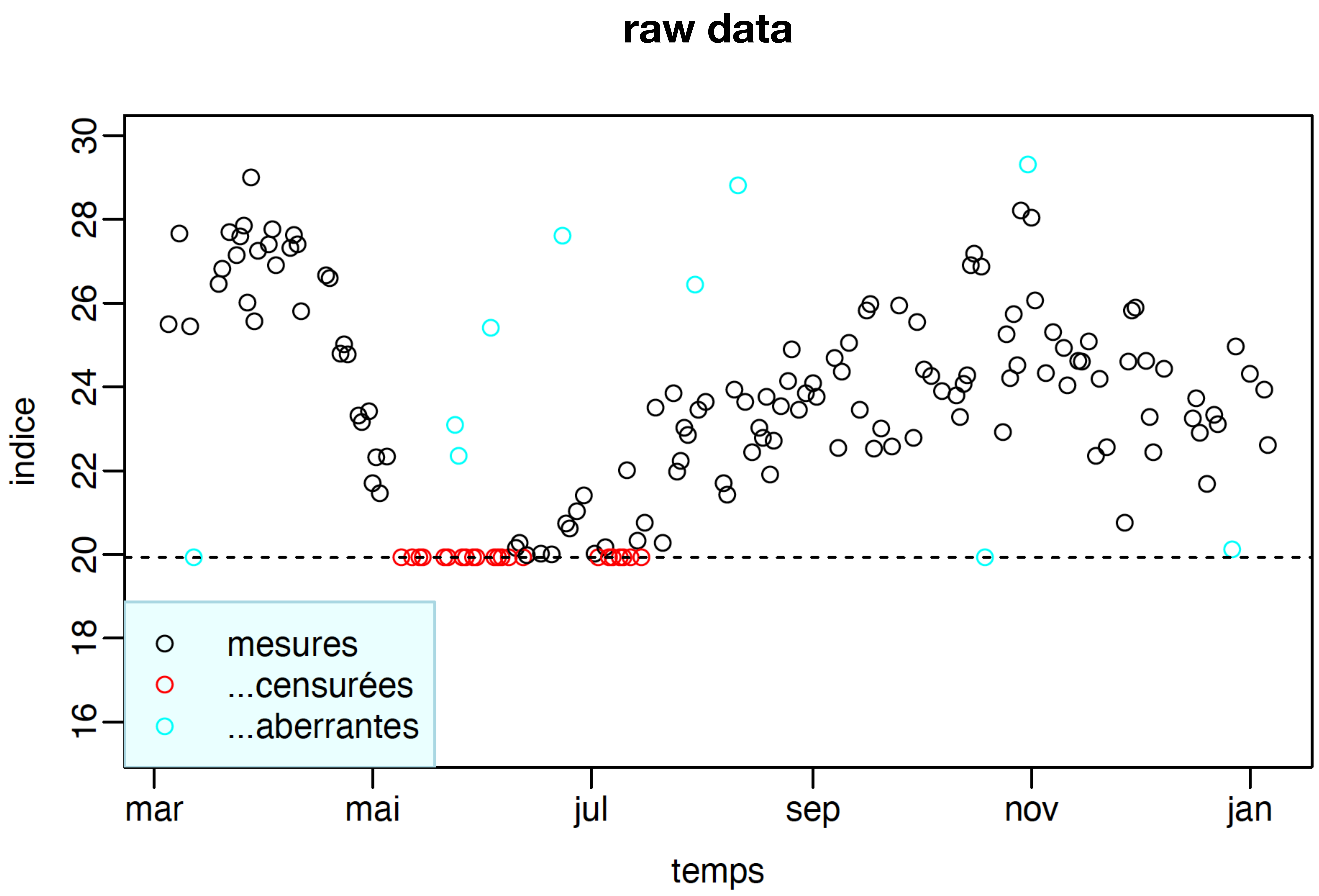
takes into account the noise (errors) in the measures

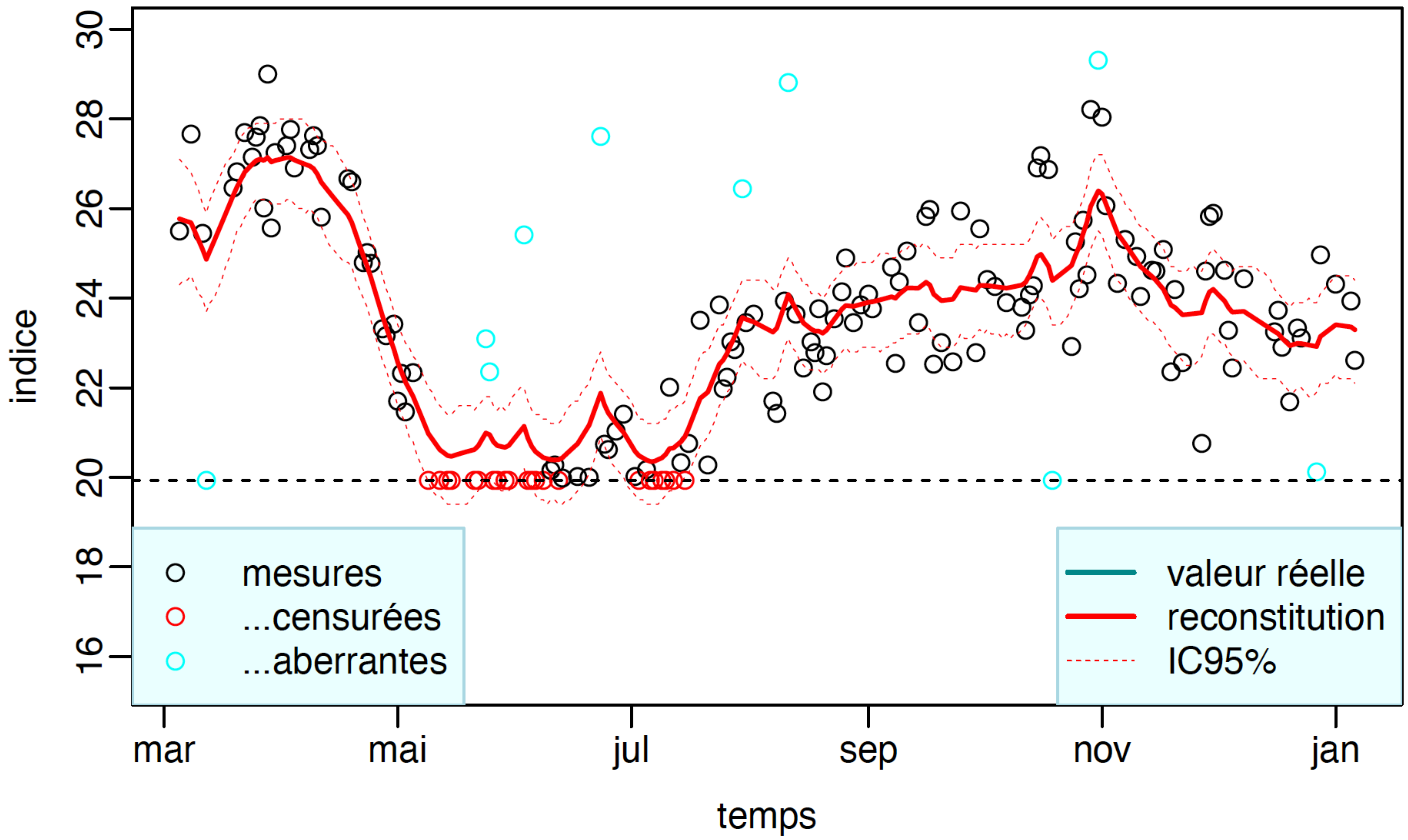
takes into account the censoring

True measures

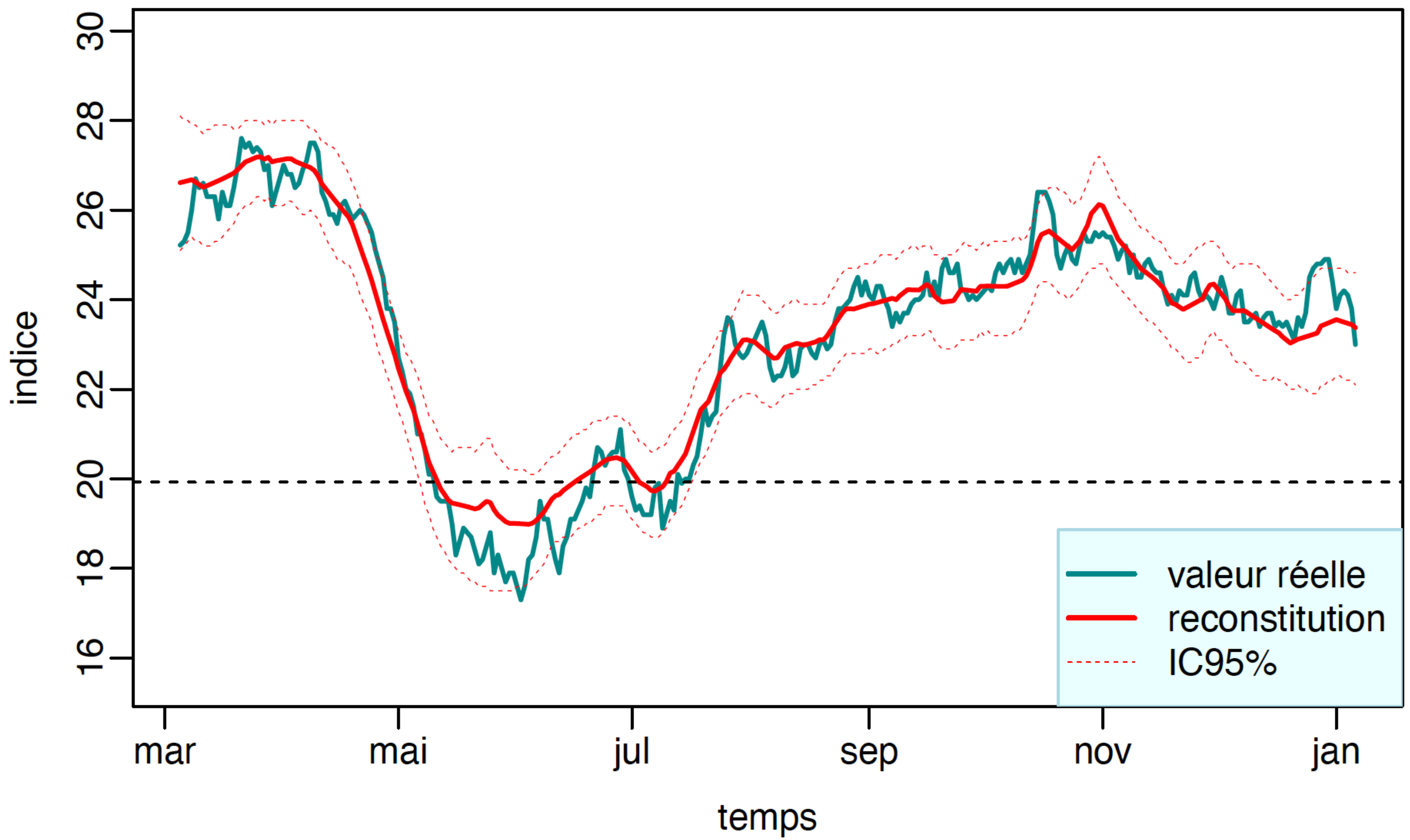



raw data
indice
30
28
26
24
22
20
18
16
mar
mai
jul
sep
nov
jan
temps
mesures
...censurées
...aberrantes

Raw treatment



Treatment taking into account outliers and LOD



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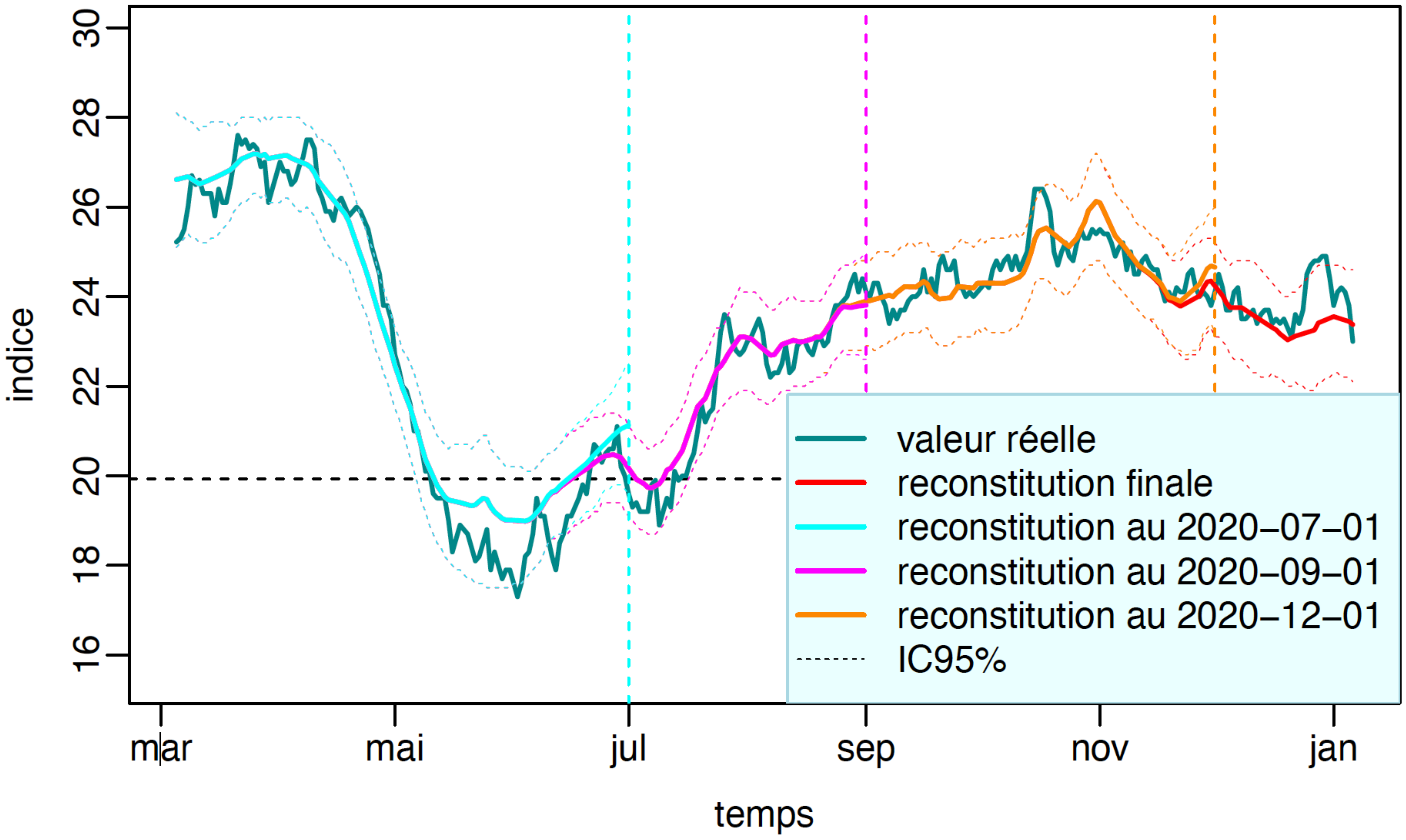

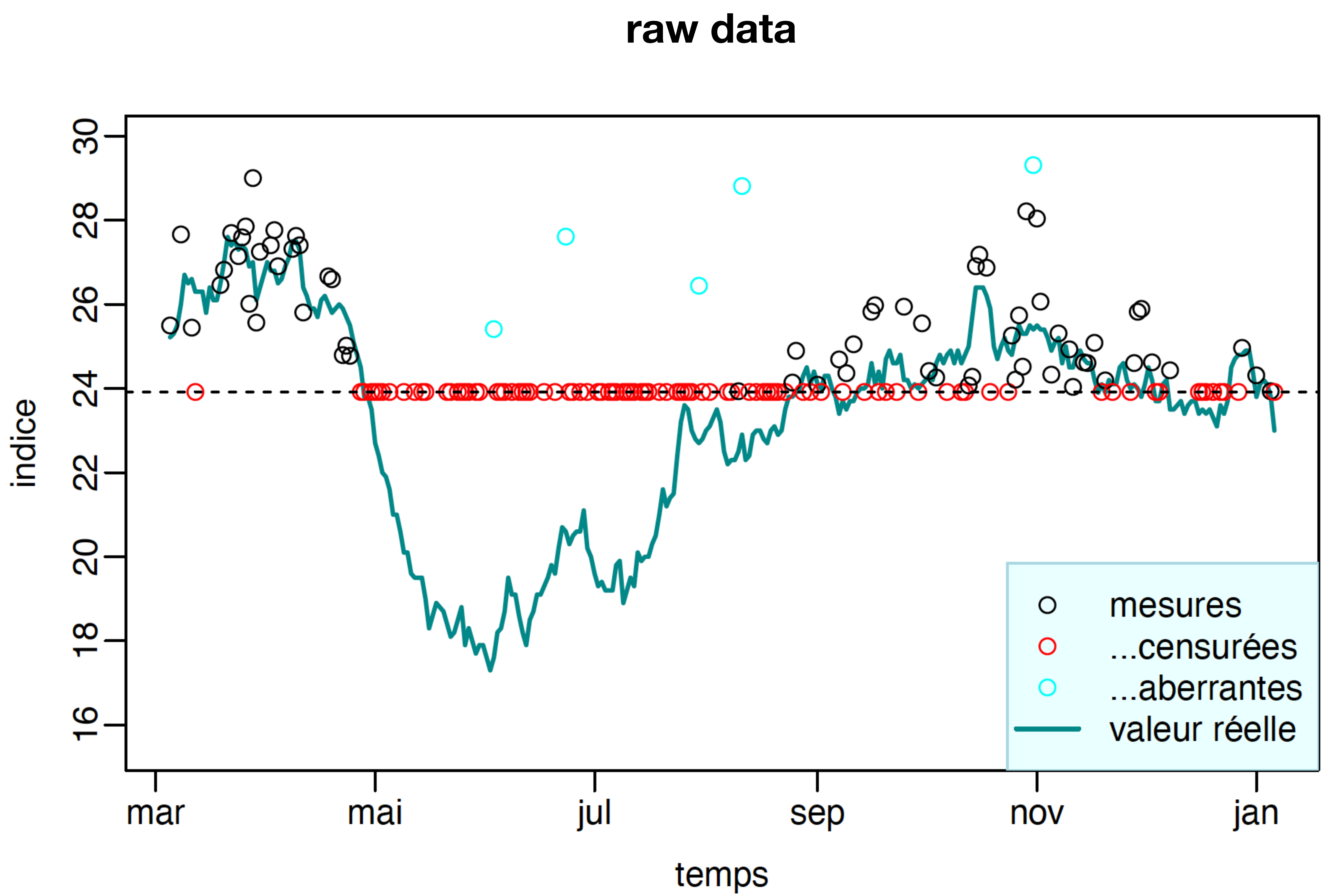
raw data
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temps
mesures
...censurées
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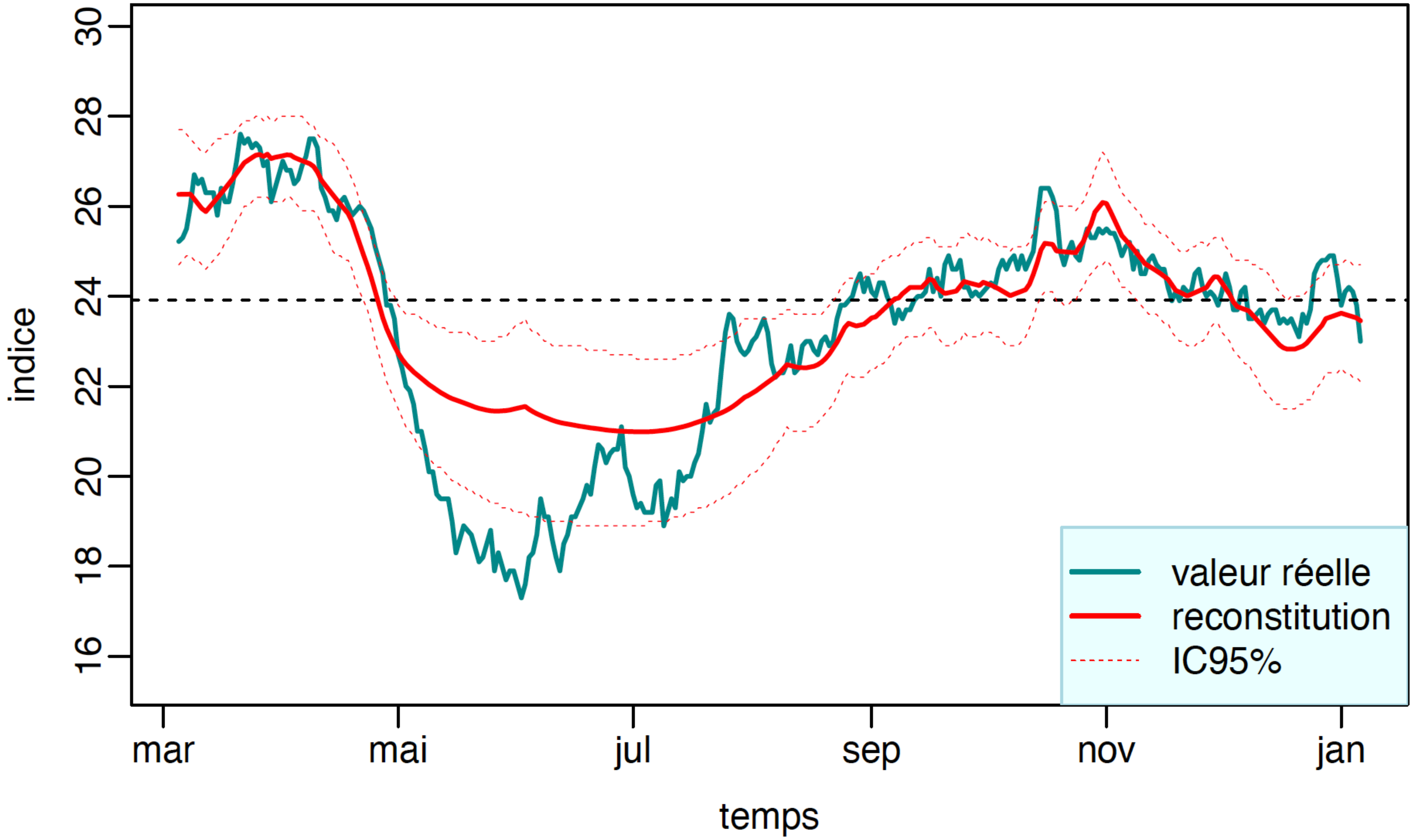
valeur réelle

Treatment taking into account outliers and LOD



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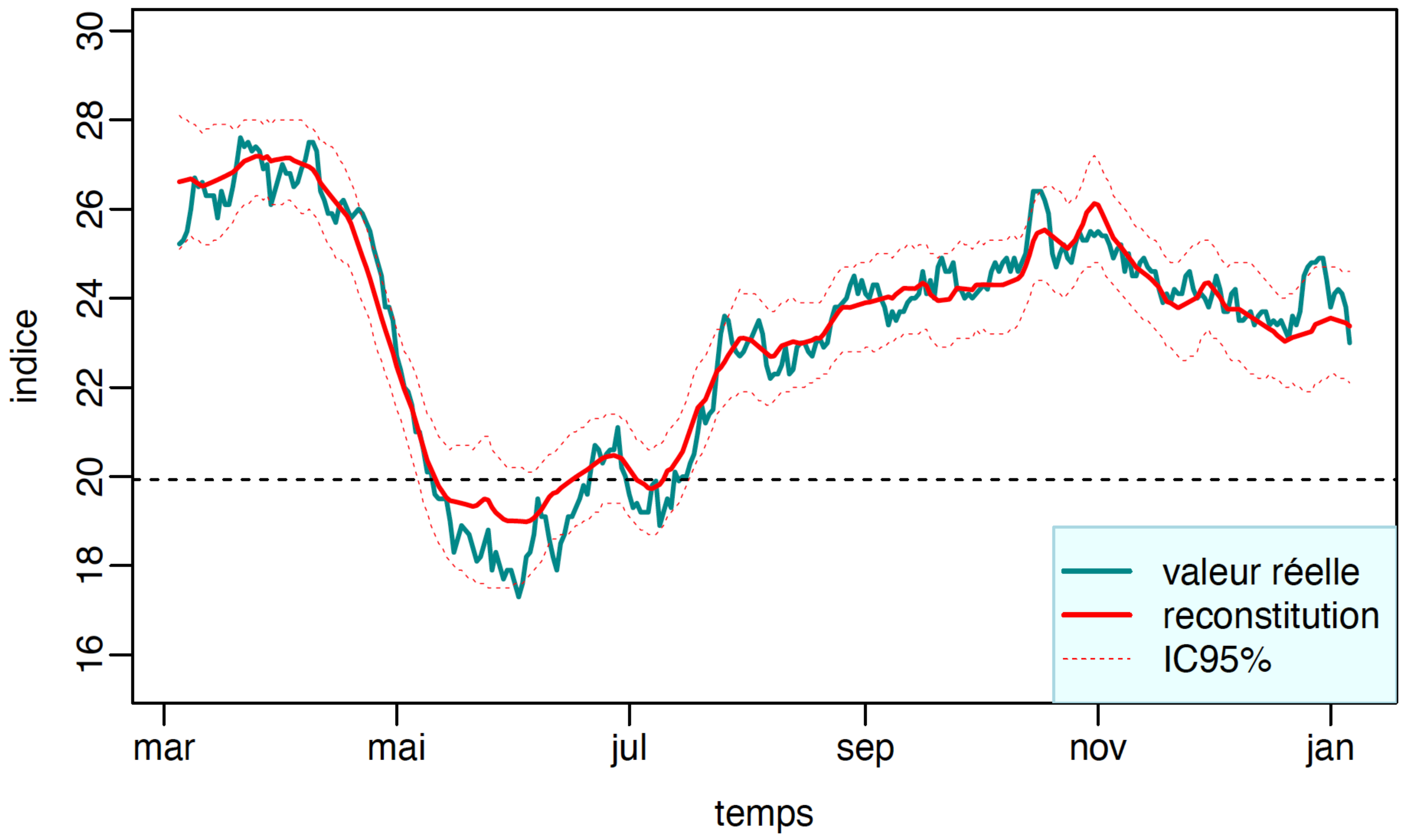

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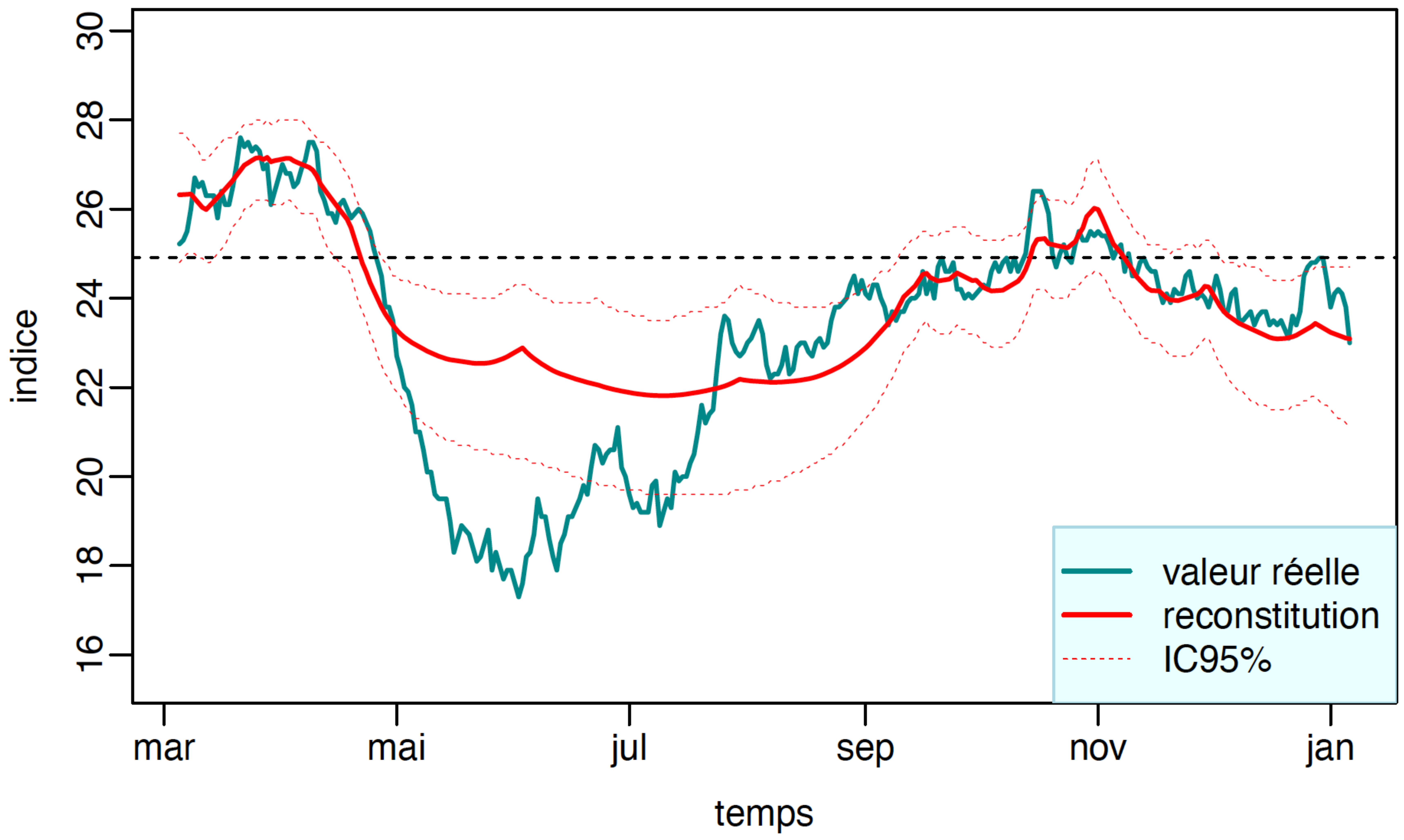


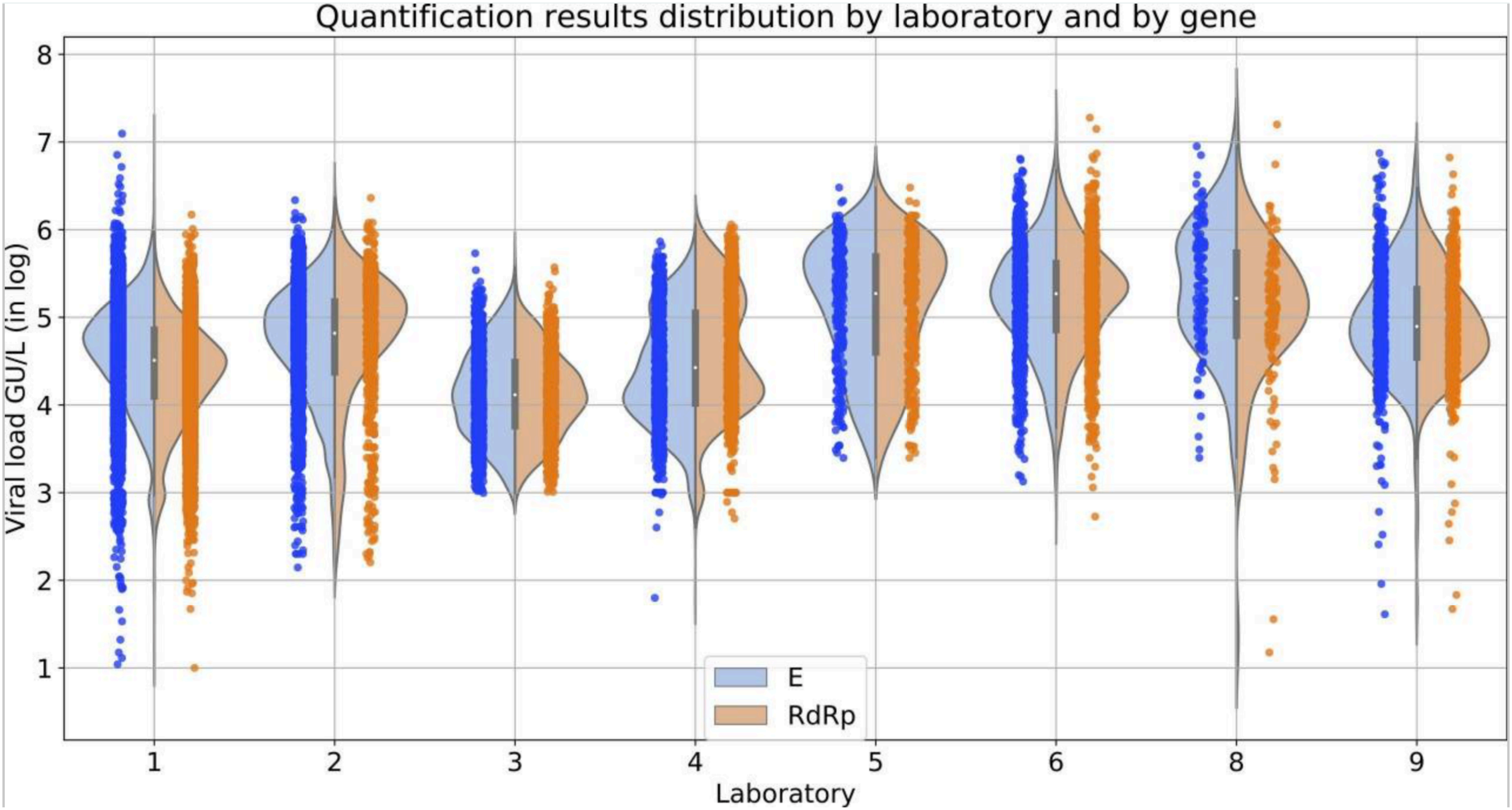
Normalization among the different laboratories

Organization of inter lab qualification and quantification

Normalization among the different laboratories

Organization of inter lab qualification and quantification

about 25 have participated : 10 were selected



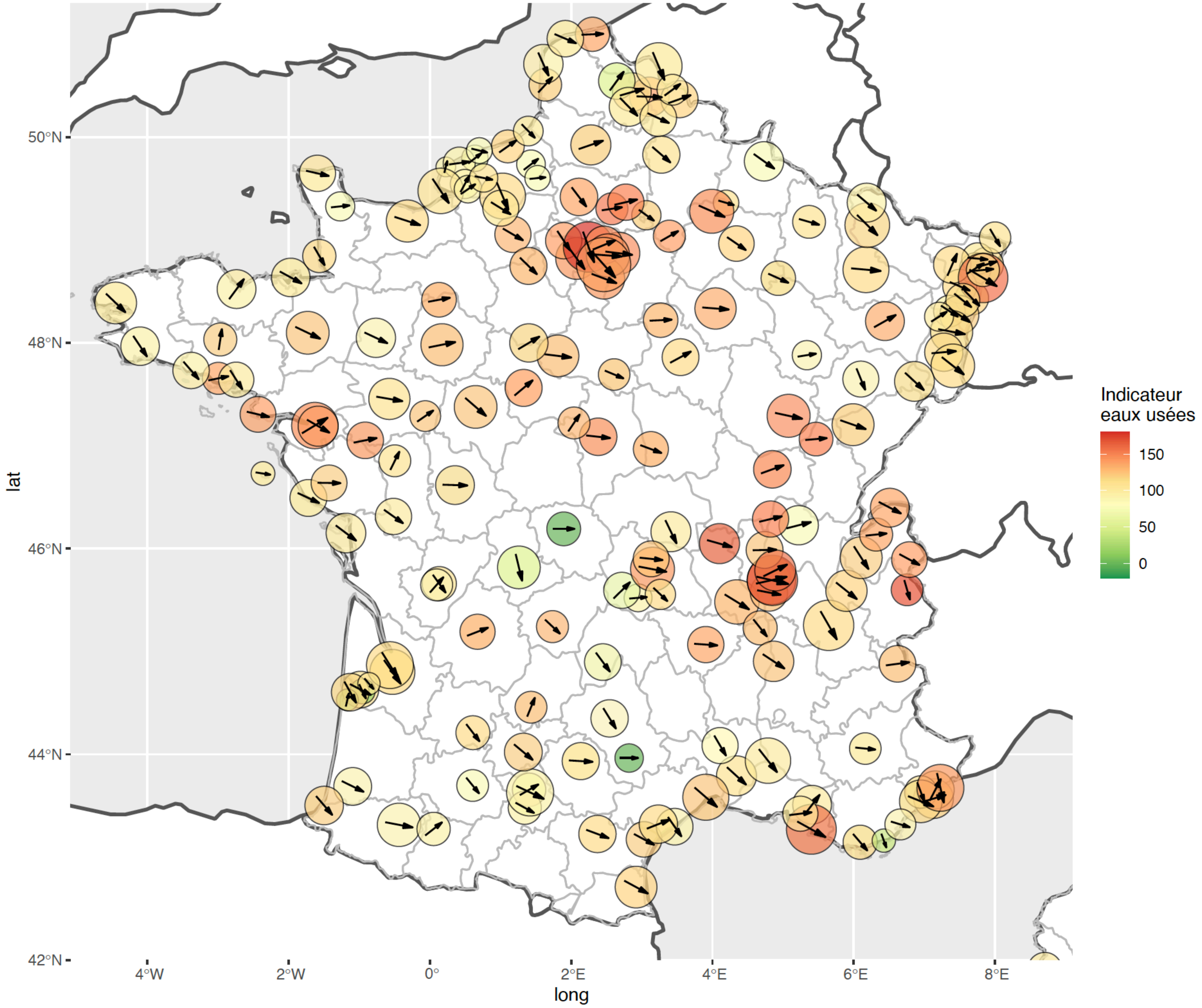
Quantification results distribution by laboratory and by gene
Viral load GU/L (in log)
8
7
6
5
4
3
2
1
E
RdRp
1
2
3
4
5
6
8
9
Laboratory

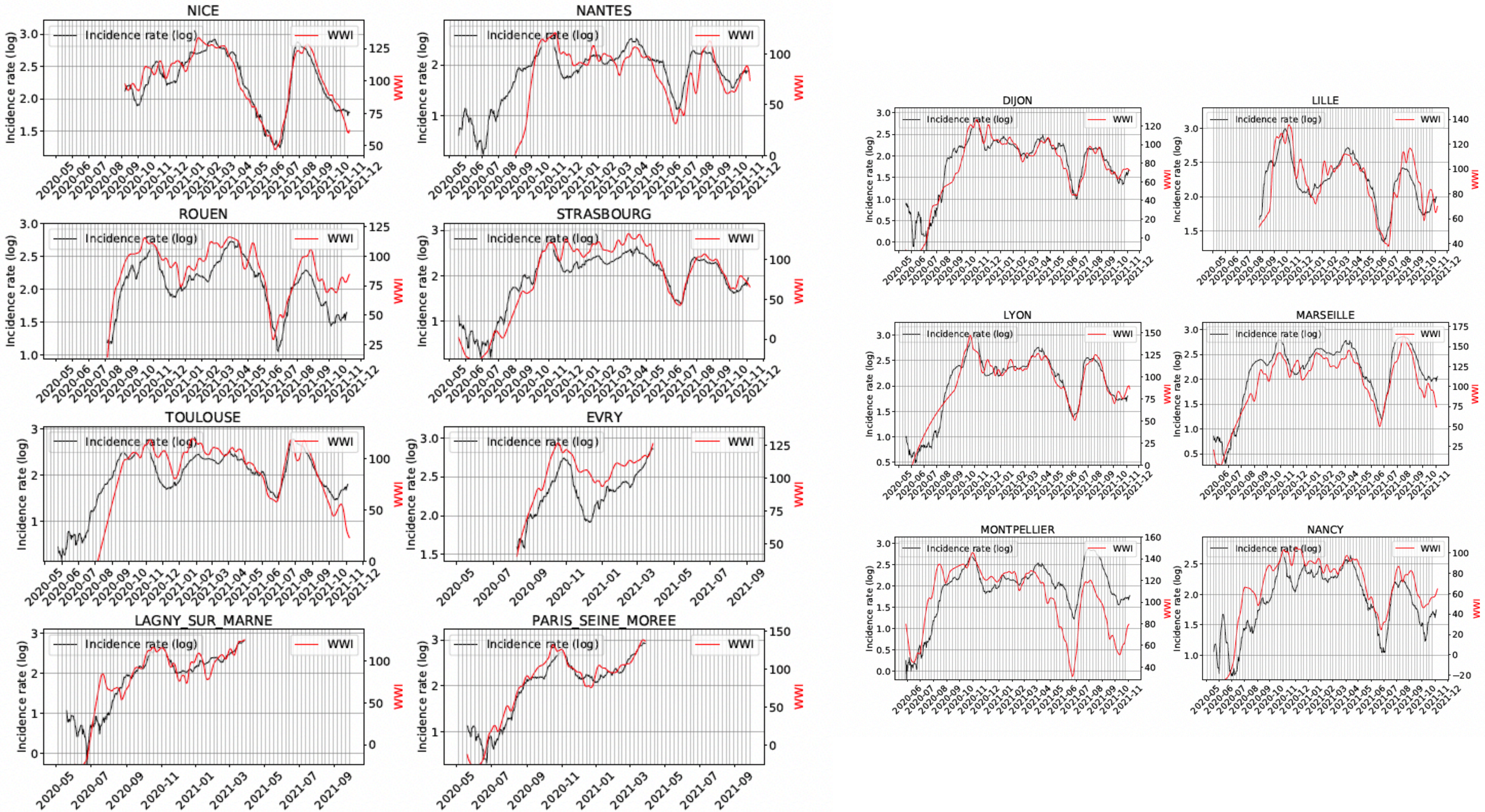
Normalization among the different laboratories

Organization of inter lab qualification and quantification

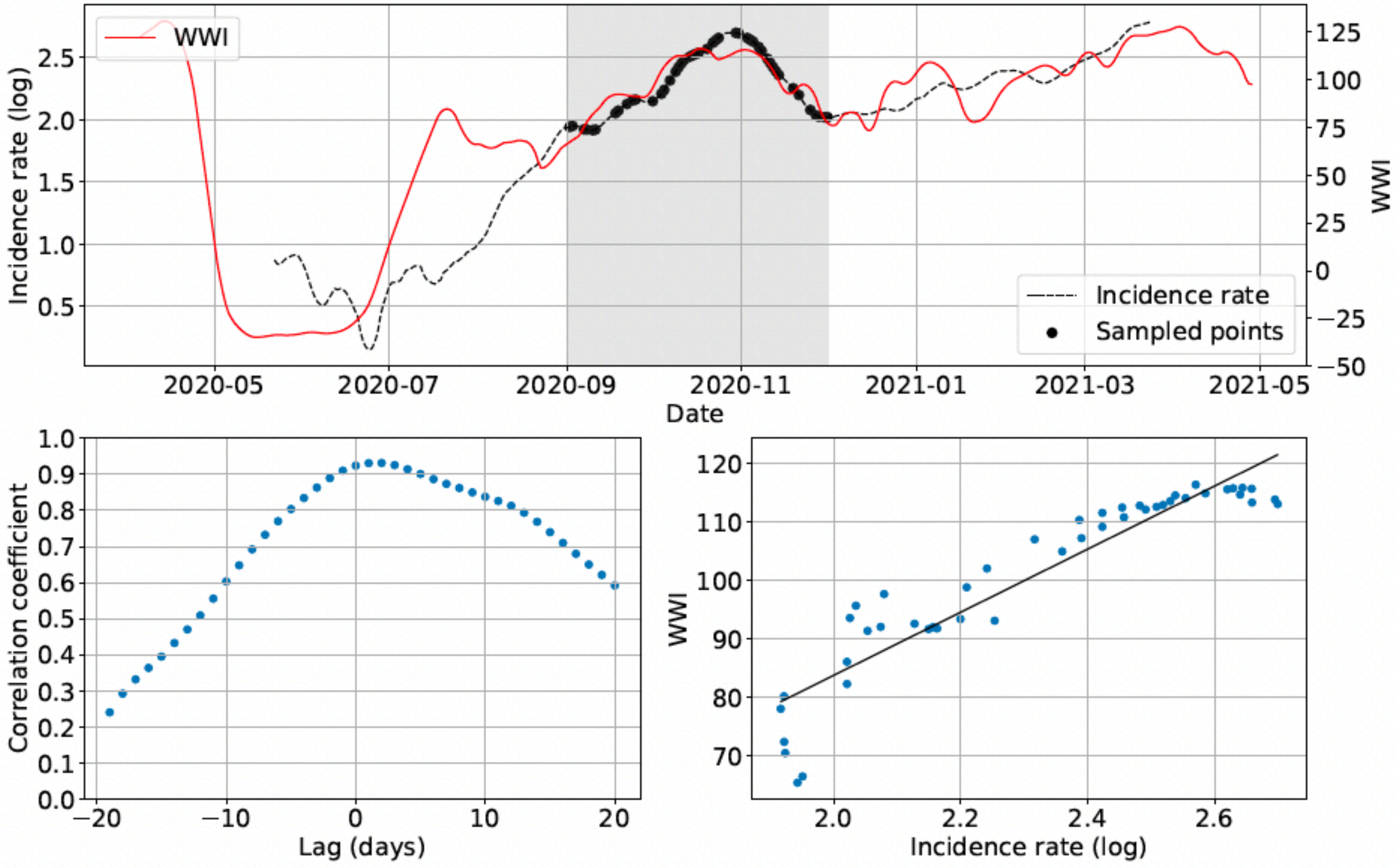
allows to present a comparable treatment over the network

Synthèse des tendances de l'évolution de l'indicateur Obépine sur 7 jours – Semaine 02




NICE
NANTES
ROUEN
STRASBOURG
TOULOUSE
EVRY
LAGNY_SUR_MARNE
PARIS_SEINE_MOREE
DIJON
LILLE
LYON
MARSEILLE
MONTPELLIER
NANCY
Incidence rate (log)
WWI

Correlation and lag between the WWI and the incidence rate



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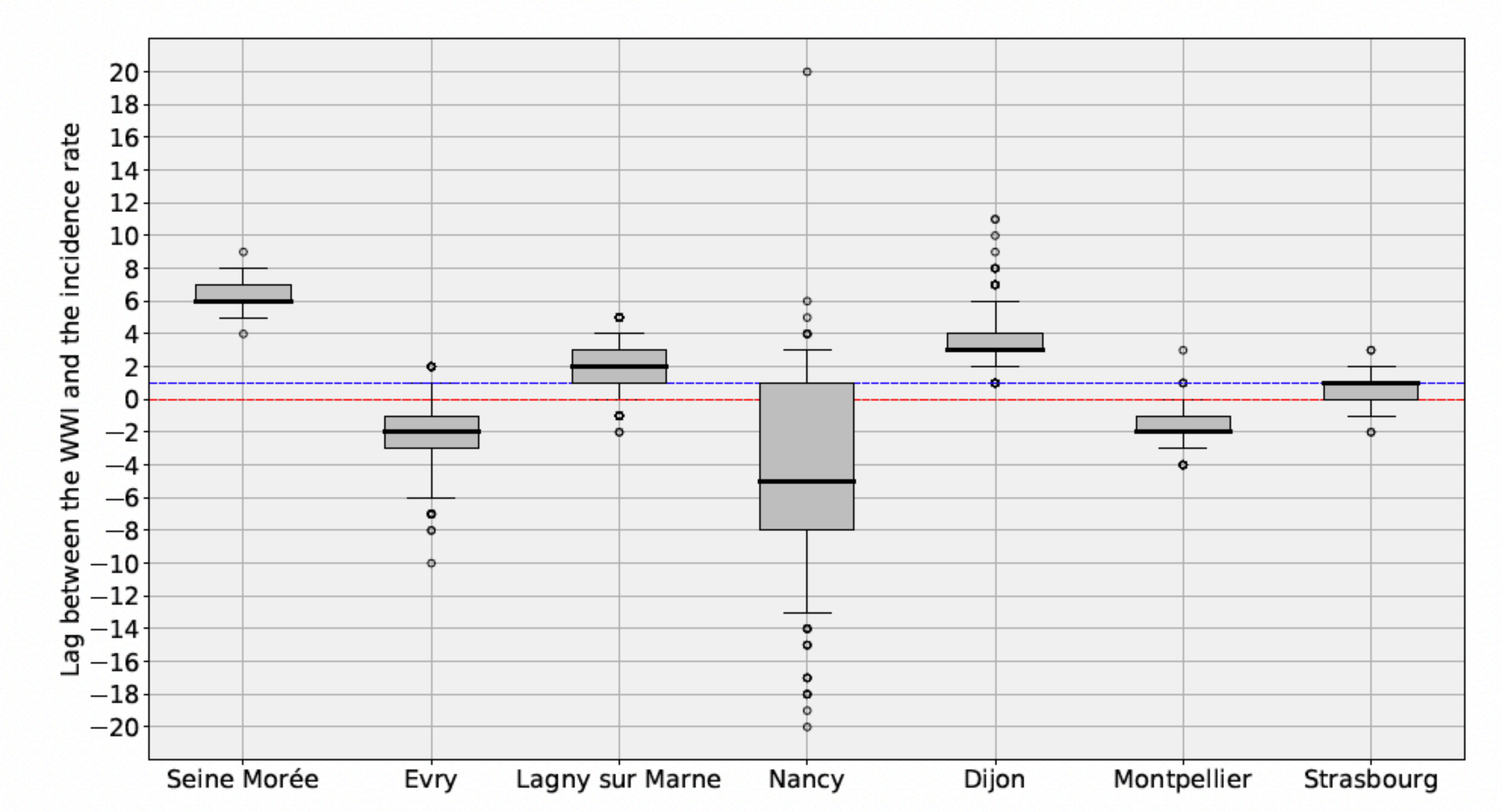
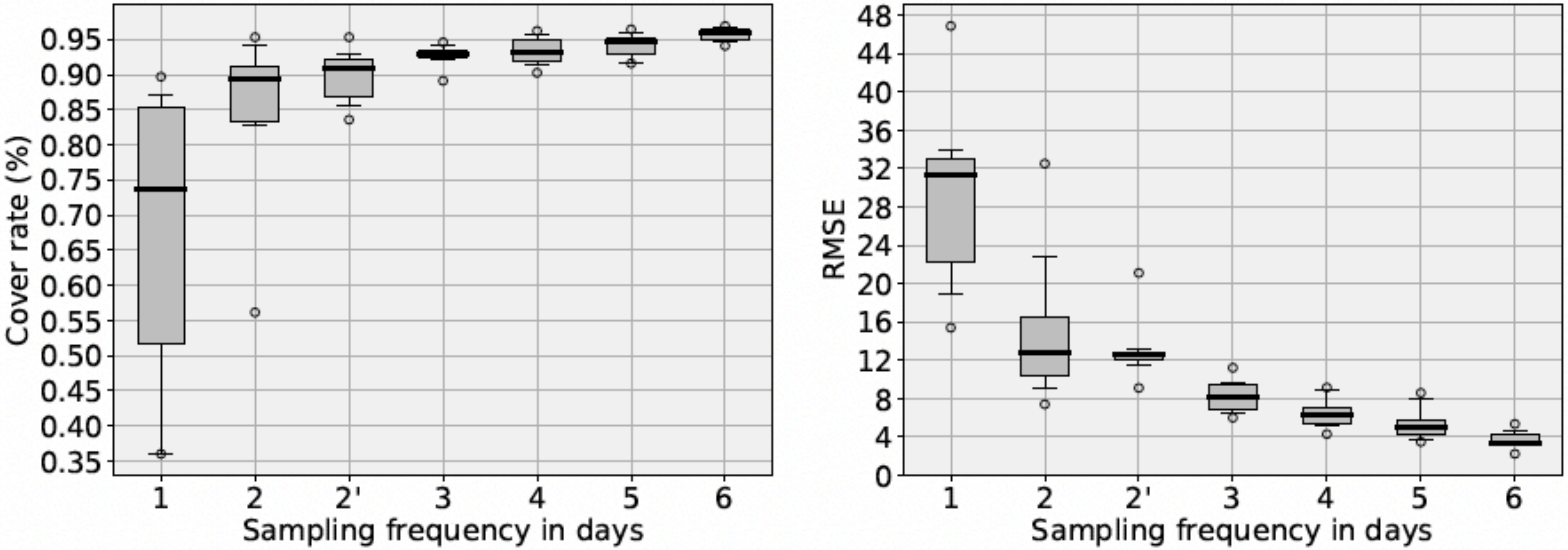


Impact of the sampling frequency



Different types of filtering processes

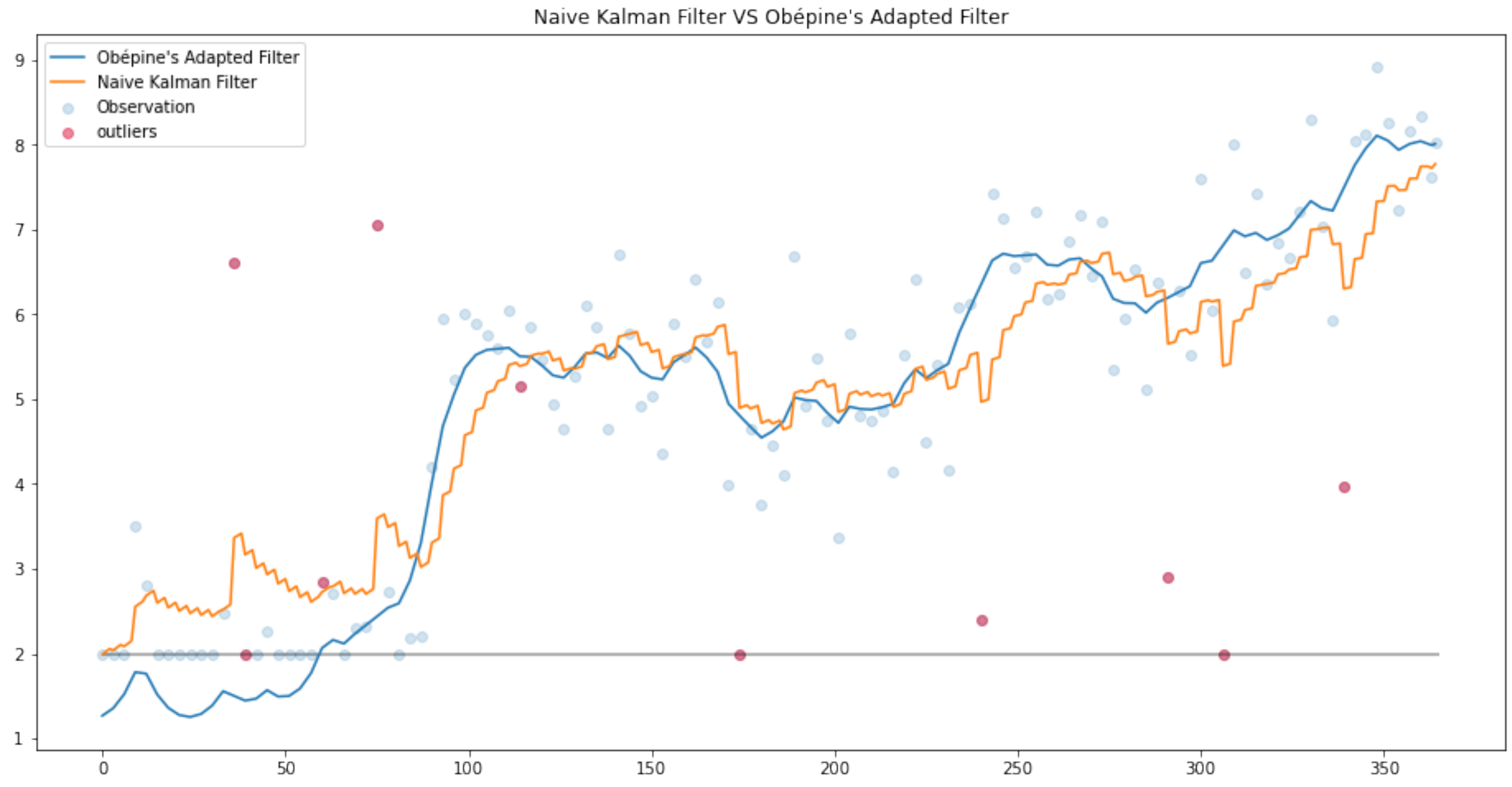
Different types of filtering processes

Data filtering methods for SARS-CoV-2 wastewater surveillance

Rezgar Arabzadeh [1], Daniel Martin Grünbacher [1], Heribert Insam [2], Norbert Kreuzinger [3], Rudolf Markt [2], Wolfgang Rauch [1]

Different types of filtering processes

Method	Reference	Sample
TUK	Mallows (1979)	Fiskeaux & Ling (1982)
KAF	Tusell (2011)	Pan *et al.* (2016)
FFT	Cochran *et al.* (1967)	Yang *et al.* (2004)
SPL[a,e]	Reinsch (1967)	Eubank (1988)
KER[a,e]	Härdle & Vieu (1992)	Speckman (1988))
SMA[a]	Hyndman (2011)	He et al. (2020)
RRM[a]	Friedman & Stuetzle (1982)	Polasek (1984)
SUP[a,e]	Friedman (1984)	Friedman & Silverman (1989)
POL[a,e]	Atkeson *et al.* (1997)	Rajagopalan & Lall (1998)
SGF[b]	Press & Teukolsky (1990)	Bromba & Ziegler (1981)
ARI[b,e]	Akaike (1969)	Lohani *et al.* (2012)
ADP[c,e]	Barak (1995)	Jakubowska & Kubiak (2004)
GAM[d,e]	Hastie (2017)	Murphy *et al.* (2019)



Naive Kalman Filter VS Obépine's Adapted Filter
Obépine's Adapted Filter
Naive Kalman Filter
Observation
outliers
9
8
7
6
5
4
3
2
1
0
50
100
150
200
250
300
350

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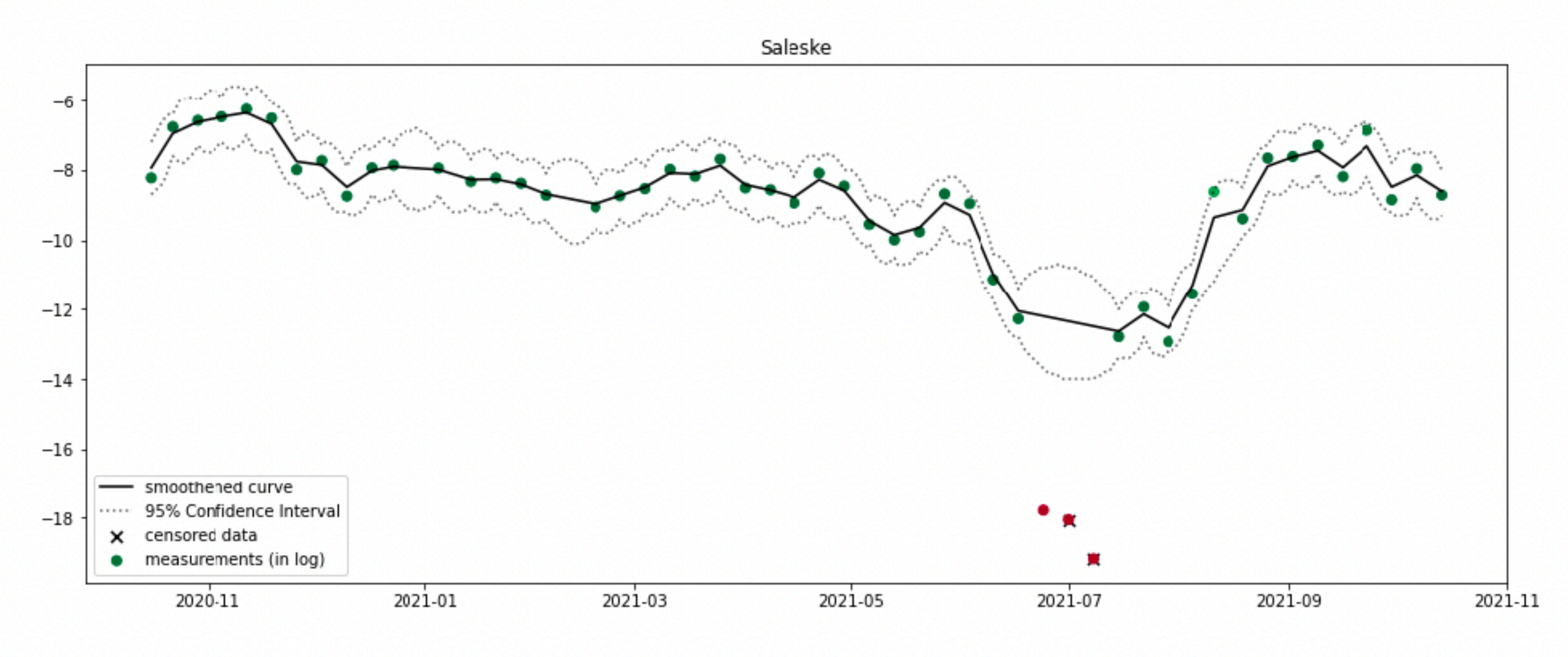

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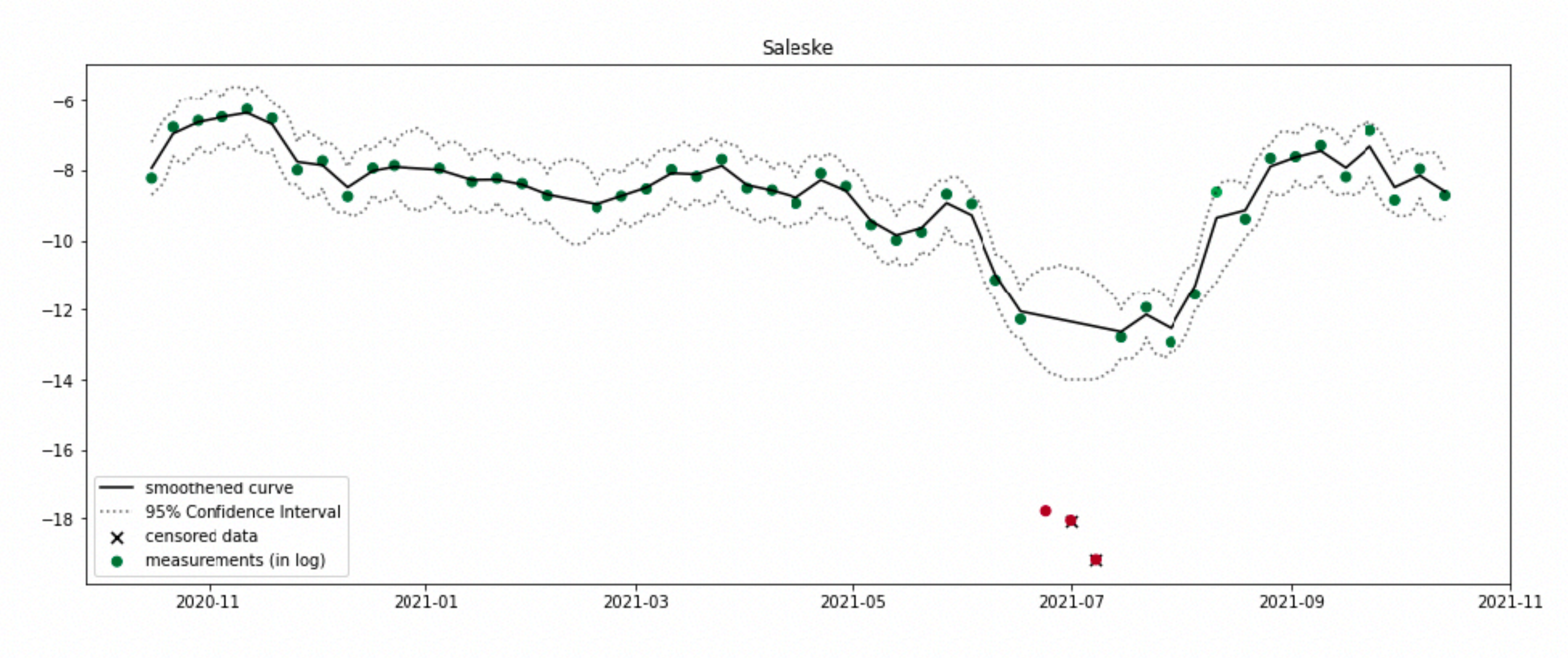

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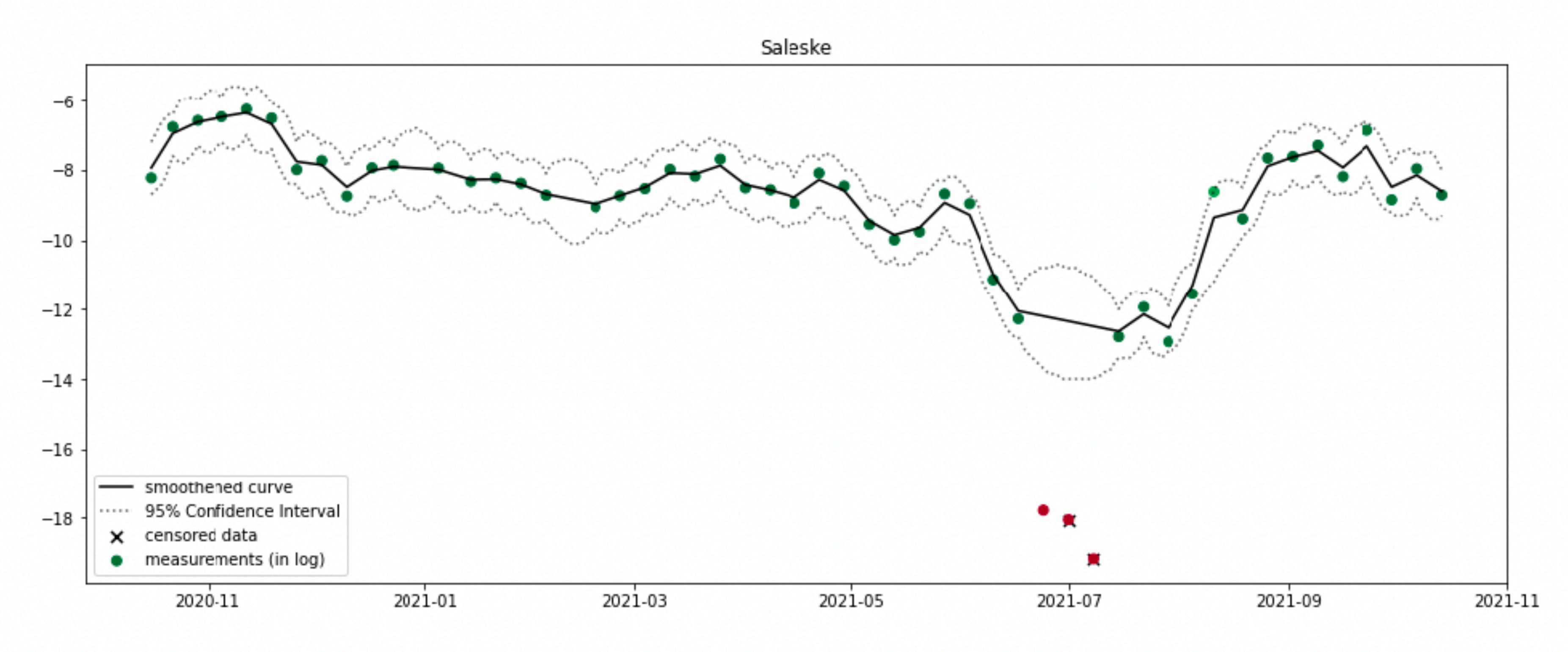

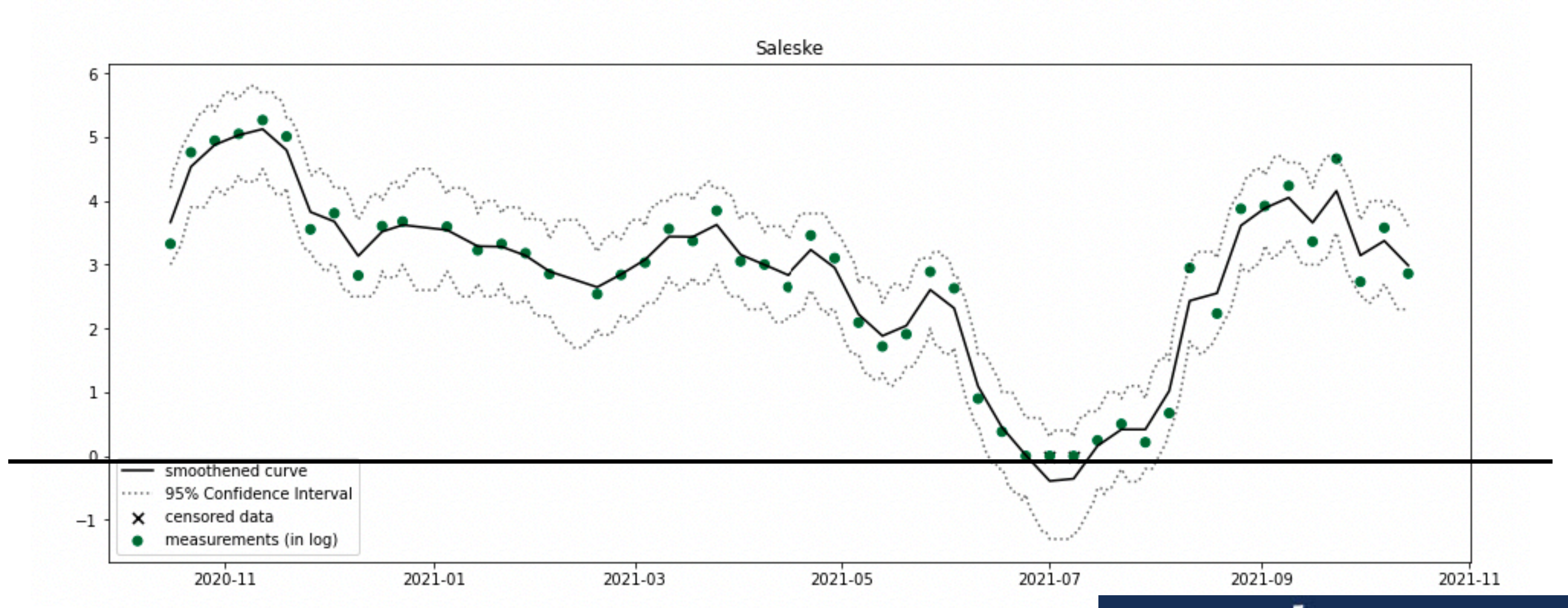

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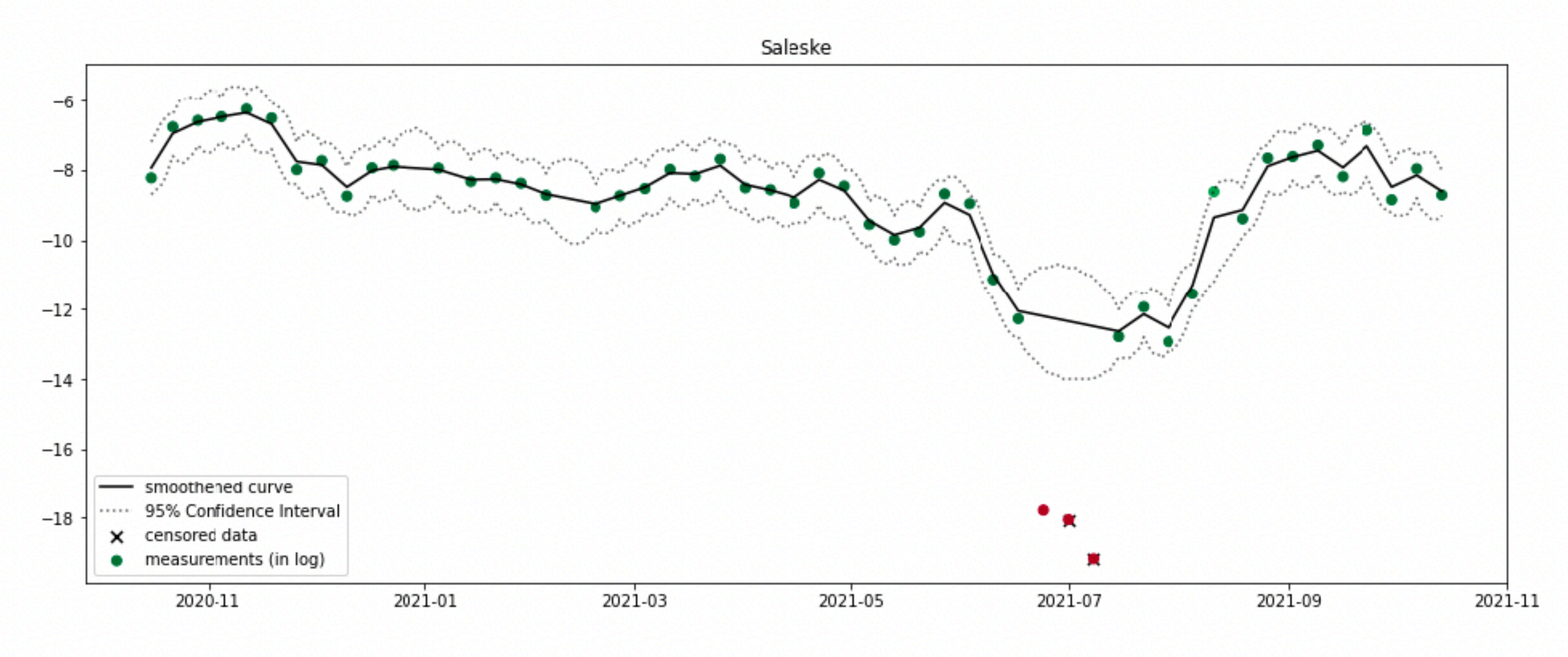
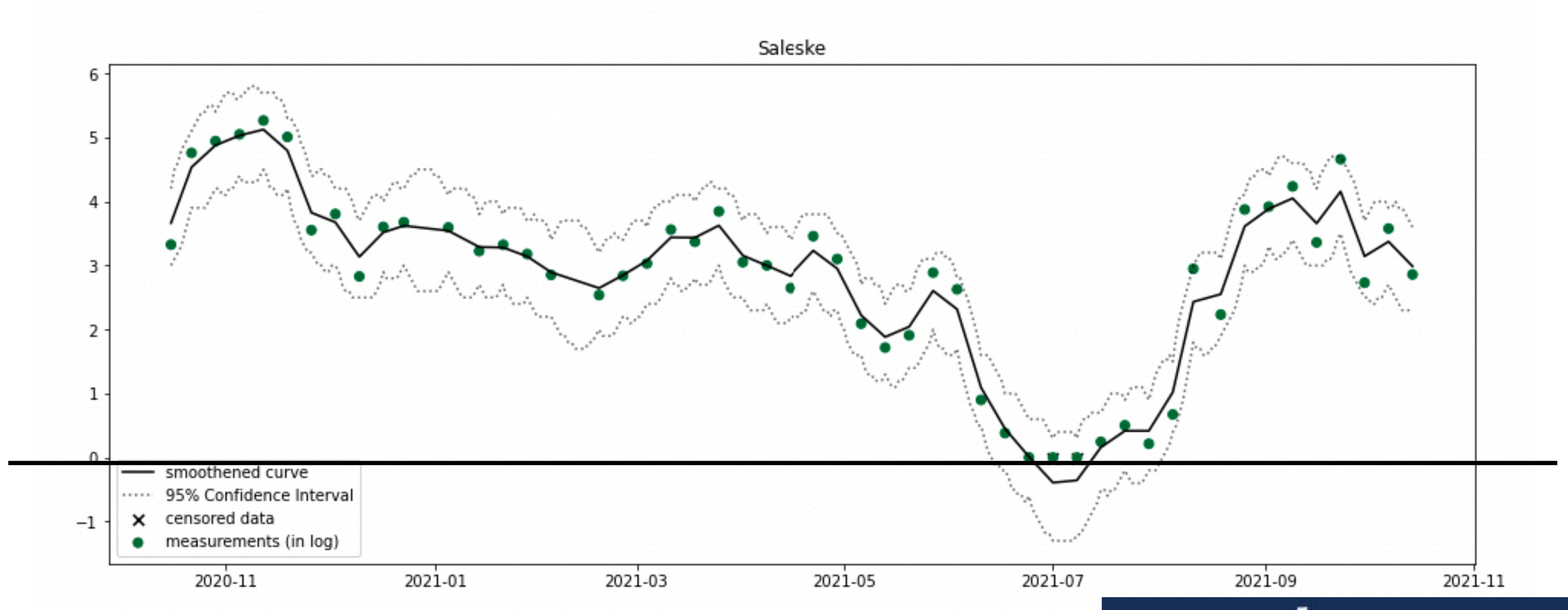


Kranj, Celje, Ljubljana, Maribor, Koper



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other collaboration with the UK government's wastewater COVID-19 monitoring team

collaborations NIB

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open for other collaborations and improve

Questions.. thanks